The Egyptian Heart Journal (2011) **63**, 87–96

Egyptian Society of Cardiology

The Egyptian Heart Journal

www.elsevier.com/locate/ehj
www.sciencedirect.com

ORIGINAL ARTICLE

Prediction of atrial fibrillation via atrial electromechanical interval after coronary artery bypass grafting

Ramy Mostafa Abd Elhalim [a], Tarek Helmy Abo El Azm [a], Khaled Hussein [b,*], Neama Ali Elmeligy [a], Heba Abdel Kader Mansour [a]

[a] *Faculty of Medicine, Cardiology Department, Benha University, Egypt*
[b] *Faculty of Medicine, Critical Care Medicine Department, Cairo University, Egypt*

Received 4 April 2011; accepted 25 May 2011
Available online 9 November 2011

KEYWORDS

Post-CABG AF;
Atrial electromechanical interval (AEMI);
Tissue Doppler imaging (TDI)

Abstract *Objectives:* We sought to analyze the value of measuring atrial electromechanical interval (AEMI) in predicting post coronary artery bypass grafting (CABG) atrial fibrillation (AF).
Background: Atrial fibrillation is the most common arrhythmia after CABG with as many as 10–40%. Several predictors are associated with the development of AF after cardiac surgery.
Methods: At least 30 patients; 18 males and 12 females (mean age 53 + 12 years) with ischemic heart disease diagnosed by coronary angiography and underwent CABG enrolled in the study. Pre-operative data were collected including laboratory, 12-lead ECG to measure P wave duration and P wave dispersion, trans-thoracic echocardiography to measure LV dimensions, ejection fraction, and LA volume. Pre-operative tissue Doppler imaging (TDI) was used to measure atrial electromechanical interval (AEMI) in milliseconds from the onset of P wave on the surface electrogram till the onset of atrial systole (Am).
Results: Our patients were classified into two groups, group I with documented post CABG AF and group II with no AF. It was found that the mean value of AEMI in group I patients was significantly longer; 136 + 5.6 vs 93.7 + 19 ms in group II patients ($P < 0.001$). Using receiver operator characteristic (ROC) analysis, it was found that the cutoff value of AEMI as a predictor of post CABG AF was 120 ms which achieves 100% sensitivity and 99% specificity. It was found also

* Corresponding author.
E-mail addresses: khaledccu@hotmail.com, khldsalama@gmail.com (K. Hussein).

Peer review under responsibility of Egyptian Society of Cardiology.
doi:10.1016/j.ehj.2011.09.005

ELSEVIER

Production and hosting by Elsevier

significantly increased P wave duration and dispersion in group I patients compared to group II (97.7 ± 3 vs 94 ± 3.9 ms; $P = 0.02$ and 26 ± 4.7 vs 23 ± 4.7; $P = 0.04$, respectively).
Conclusion: using AEMI as a predictor of post CABG AF is a valuable marker which carries high sensitivity and specificity.

1. Introduction

Atrial fibrillation (AF) is the most common arrhythmia after coronary artery bypass grafting (CABG), with a rate of occurrence of 17–33%.[1]

Patients undergoing CABG and combined valve surgery have a higher incidence of postoperative AF than do patients having CABG alone.[2,3]

The peak of AF incidence occurs between 2 and 4 days after operation, with <10% happening on the first postoperative day.[4]

AF after CABG is self-limiting in most cases, but even when it is uncomplicated; it requires additional medical treatment and a prolonged hospital stay and has the concomitant extra costs of operative treatment.[3–5]

Post-CABG AF is known to be a potential risk for systemic thromboembolism, hemodynamic compromise, and even stroke.[2–4,6]

Therefore, it is advisable that prophylactic therapy with amiodarone or atrial pacing be administered to decrease its incidence.[7,8]

However, prophylactic treatment to prevent AF with intravenous amiodarone is not cost-effective if given to all patients. In addition, such treatment may have unfavorable side effects. On the other hand, the prophylaxis of the whole patient population undergoing CABG is not reasonable and this renders the identification of at-risk patients of post-CABG AF very helpful.[9]

To that end, several studies have used different ECG and echocardiographic parameters (e.g., P-wave duration and left atrial [LA] volume). They all, however, have limitations.[1]

Using M-mode Doppler tissue, Omni and colleagues[10] have evaluated the ability of the atrial electromechanical coupling to detect atrial impairment in paroxysmal AF. They found that the time interval from the onset of the P wave to the beginning of the backward motion of the mitral was prolonged in paroxysmal AF.

In light of the above-mentioned studies, we hypothesized that the atrial electromechanical interval (AEMI) as a measure of atrial impairment could be helpful in detecting patients facing the risk of post-CABG AF.

2. Aim of the work

I. To evaluate the atrioelectromechanical interval and its role in prediction of post-CABG AF.
II. Search for other significant predictors of post-CABG AF.

3. Patients and methods

Thirty patients with ischemic heart disease were included in the study. They were diagnosed by coronary angiography and underwent coronary artery bypass surgery in Cairo University Hospital during the period between February and July 2010.

Exclusion criteria of these patients include:

- history of atrial arrhythmia,
- valvular heart disease,
- associated surgery, e.g. mitral valve repair,
- previous usage of antiarrhythmic drugs, and
- uncontrolled heart failure.

All patients included in the study were subjected to:
Pre-operative assessment:

- Fully history and clinical examination.
- Pre-operative data included: gender, age, history of hypertension, diabetes and history of smoking.
- Pre-operative coronary angiography data were included.

Pre-operative laboratory investigations done include:

- random blood sugar,
- serum urea and creatinine,
- serum Na, K^+ and Mg^{++},
- serum albumin,
- complete blood count (CBC),
- liver enzymes, and
- lipid profile.

Pre-operative medications: ACEI, statins, nitrates, calcium blockers, beta blockers and lanoxin were considered.

Pre-operative ECG: The P wave duration and P wave dispersion were calculated. (The P wave dispersion is the difference between the longest and shortest P wave duration in the 12-lead ECG.)[11]

Pre-operative echocardiography: All patients underwent a pre-operative trans-thoracic echocardiography with a tissue Doppler imaging analysis (using ALT, HDI 5000 with 3–5 MHz transducer) during the week before the surgery. Tissue Doppler imaging allows direct non invasive measurements of myocardial velocities and displacement. It was done by an experienced investigator at the Critical Care Department, Cairo University Hospital. The left ventricular dimensions, systolic, diastolic and regional function all were routinely assessed.LA volume was determined by tracing the endocardium from the 4-chamber view at the maximal atrial dimension according to ASE recommendation for chamber quantification by Lang et al.[12] (Fig. 1). The left ventricular ejection fraction by 2-dimensional echocardiography was obtained via a modified biplane Simpson's method from the apical 4- and 2-chamber views.[13]

All patients were subjected to tissue Doppler imaging (TDI) calculating atrial electromechanical interval (AEMI) which is measured from the transmitral Doppler spectra of five consecutive cardiac cycles. Myocardial velocities obtained with TDI were recorded using a standard pulsed wave Doppler technique with the sample volume placed at the junction of the left ventricle lateral wall with the mitral lateral annulus from the 4-chamber view. The AEMI was measured in milliseconds as time intervals from the onset of the P wave to the beginning of the atrial systole (Am) at the lateral side of the left atrium (left side)[14] (Figs. 2 and 3).

Intra-operative technique: The same technique was used in all patients to unify the steps all through the study and exclude intra operative causes of AF. A median sternotomy was performed in all the patients. Standard cardiopulmonary bypass was established by ascending aortic cannulation and with a single 2-stage venous cannulation of the right atrium. Myocardial protection was achieved by ante-grade intermittent warm blood cardioplegia every 15 min. All the patients received total revascularization.

Post-operative assessment includes:

- Post-operative laboratory investigations as serum hemoglobin, serum potassium and magnesium.
- All patients were observed for the occurrence of post-operative AF.
- Post-operative echocardiography.

Routine post-operative 2D conventional echocardiography was done to exclude any intra operative structural lesions or post-operative left ventricular dilatation and to assess cardiac function post CABG.

Classification of patients: Patients were classified into two groups according to the occurrence of post-operative AF.

- Group I: Patients who developed post-operative AF.
- Group II: Patients who did not develop post-operative AF.

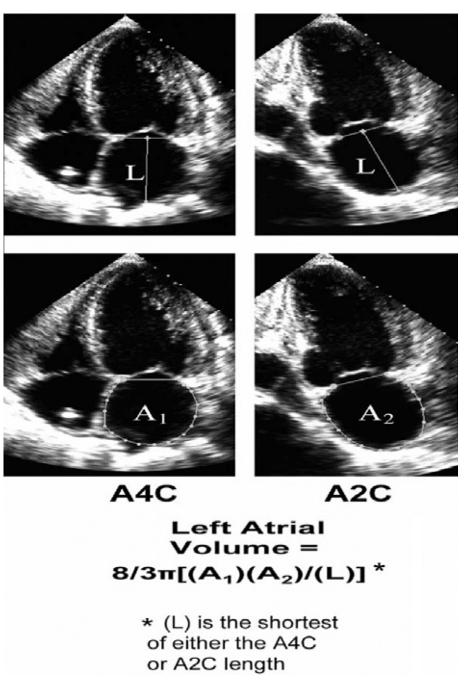

Figure 1 Measuring LA volume.[12]

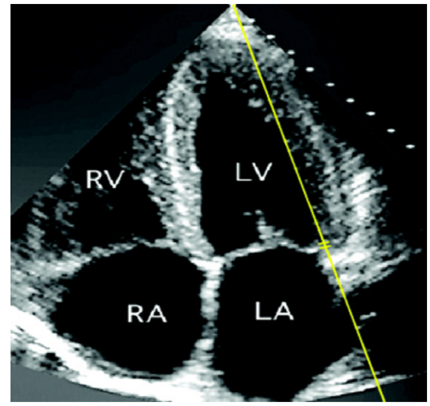

Figure 2 Four-chamber view. The sample volume was placed at the junction of the left ventricle lateral wall with the mitral lateral annulus.[14]

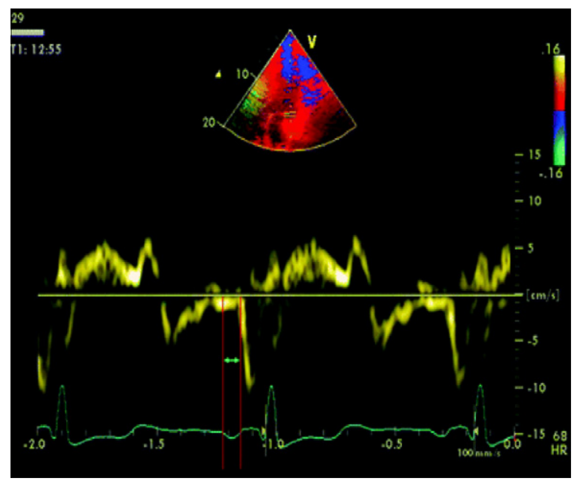

Figure 3 Four-chamber view. Calculation of AEMI (from the beginning of the P wave on the ECG to the beginning of Am wave on TDI.[14]

3.1. Statistical analysis

Data were statistically described in terms of range, mean ± standard deviation (±SD), median frequencies (number of cases) and percentages when appropriate. Comparison of quantitative variables between the study groups was done using Mann Whitney U test for independent samples. For comparing categorical data, Chi square (χ^2) test was performed. Exact test was used instead when the expected frequency is less than 5. Accuracy was represented using the terms sensitivity and specificity. Receiver operator characteristic (ROC) analysis was used to determine the optimum cutoff value for the studied diagnostic markers. A probability value (P value) less than 0.05 was considered statistically significant. All statistical calculations were done using computer programs Microsoft Excel 2003 (Microsoft Corporation, NY, USA) and SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows.

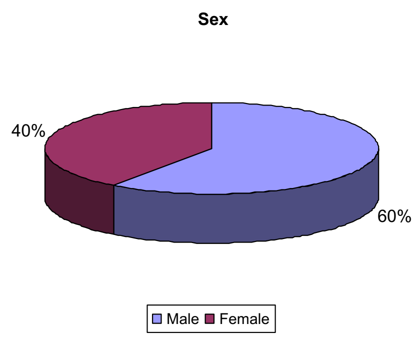

Figure 4 Sex distribution among the studied patients.

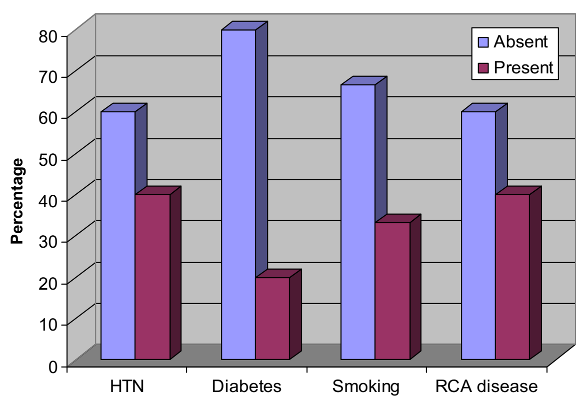

Figure 5 Pre-operative demographic data.

4. Results

This study included 30 patients with ischemic heart disease diagnosed by coronary angiography and underwent CABG surgery in Cairo University Hospital during the period between February and July 2010.

Table 1 Criteria of enrolled patients.

Criteria	Number	Percent
Sex		
Male	18	60
Female	12	40
HTN		
Absent	18	60
Present	12	40
Diabetes		
Absent	24	80
Present	6	20
Smoking		
Absent	20	66.6
Present	10	33.3
RCA disease		
Absent	18	60
Present	12	40

4.1. Demographic and clinical characteristics of the patients

- The mean age of patients enrolled was 53.43 ± 8.44 years (range from 35 to 67 years).
- 60% of patients enrolled in the study were male (18 patients) (Fig. 4). Forty percent of patients were hypertensive (12 patients), diabetes was found in only 20% of patients (6 patients). One-third of patients (33.3%) were smokers, RCA disease was present in 40% of patients (12 patients) (Fig. 5).

All criteria of patient are demonstrated in Table 1.

Patients included in the study (30 patients) were classified into two groups:

- Group I: patients who developed post-operative AF (10 patients).
- Group II: patient who did not develop post-operative AF (20 patients).

As shown in Table 2 there was no statistically significant difference between the two groups regarding age, HR, diabetes, smoking. However, the presence of RCA disease showed a significant difference between the two groups as it was present in 80% in group I (having post-CABG AF) and only 20% in group II; *P value* of 0.002.

There was no statistically significant difference between the two groups regarding all pre-operative lab data as shown in Table 3, Fig. 6.

Table 2 Data of patients in the two groups.

	Group I (AF)		Group II (non-AF)		*P* value
	No. 10	33.33% (%)	No. 20	66.66% (%)	
Age	53.7		53.3		0.93
HTN	5	50	7	35	0.429
DM	2	20	4	20	0.1
Smoke	4	40	6	30	0.58
RCA disease	8	80	4	20	0.002

Table 3 Pre-operative laboratory data of the patients in groups I and II.

Variable	Group I	Group II	*P* value
RBS	146.2 mg/dl	159 mg/dl	0.868
S. creatinine	0.88 mg/dl	0.965 mg/dl	0.468
BUN	15.9 mg/dl	18.9 mg/dl	0.072
Na	135.5 meq/l	133.4 meq/l	0.223
K pre	3.73 meq/l	3.71 meq/l	0.808
Mg pre	1.96 mg/dl	1.94 mg/dl	0.839
AST	24 IU/l	26.7 IU/l	0.791
ALT	34.6 IU/l	25.83 IU/l	0.052
S. albumin	3.8 g/dl	3.91 gm/dl	0.707
Hb pre	13.35 g/dl	13.5 gm/dl	0.647
S. cholesterol	220 mg/dl	201.1 mg/dl	0.235
TG	160.6 mg/dl	137.7 mg/dl	0.078
HDL	32.8 mg/dl	32.45 mg/dl	0.910
LDL	82.5 mg/dl	78.35 mg/dl	0.171

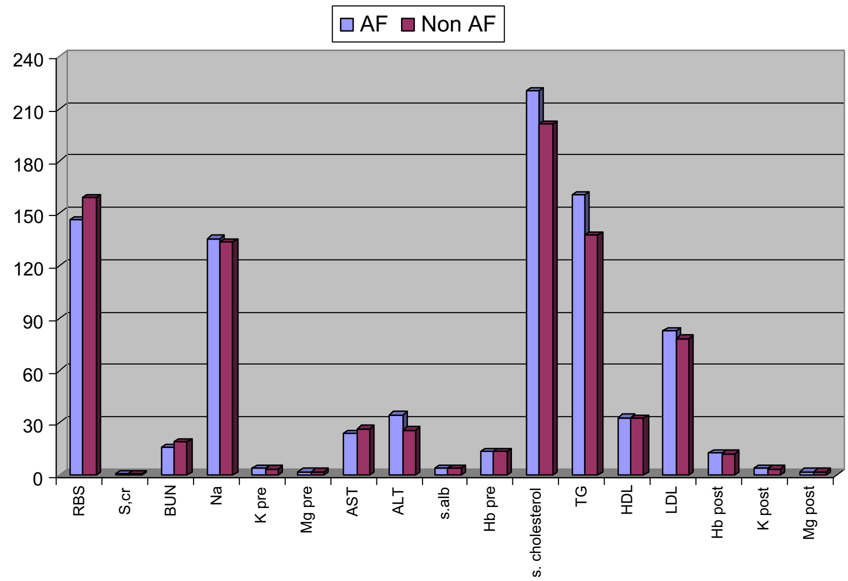

Figure 6 The relation between the laboratory findings in groups I and II.

Table 4 Post-operative laboratory data in groups I and II.

Variable	Group I	Group II	*P* value
Hb post	12.7 g/dl	12.4 g/dl	0.924
K post	3.76 meq/l	3.71 meq/l	0.562
Mg post	1.8 mg/dl	2 mg/dl	0.004

Table 5 Comparison between the pre-operative mean P wave duration in the two groups.

Maximum P wave duration (ms)	Group I	Group II	*P* value
Range	92–103	85–100	
Mean value	97.7	94	0.022
Standard deviation	3.01	3.94	

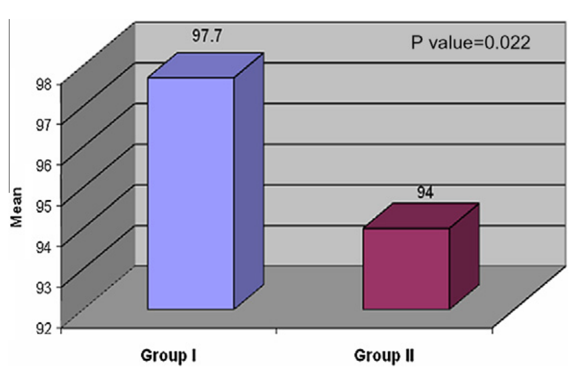

Figure 7 The pre-operative P wave duration in groups I and II.

As shown in Table 4, there was no statistically significant difference in the mean values of the post-operative laboratory data. The only variable that showed a significant difference was the post-operative Mg level, where the mean value in group I was 1.835 vs 2.00 mg/dl in group II with a *P value* of 0.004.

4.2. ECG findings in groups I and II

As shown in Table 5, data obtained from the pre-operative 12-lead ECG showed a maximum duration of P wave among patients in group I ranging from 92 to 103 with a mean value of 97.7 ± 3.1 ms and those in group II ranged from 85 to 100 with a mean value of 94 ± 3.94 ms. The difference between the two groups was statistically significant, *P* value = 0.022 (Fig. 7).

As shown in Table 6, no significant difference was found between mean post-operative P wave duration in groups I and II (*P* = NS) (Fig. 8).

As shown in Table 7, the calculated mean P wave dispersion in group I patients was 26 ± 4.7 ms (range from 19 to 32 ms) compared to 23 ± 4.7 ms (range from 19 to 28 ms) with a significant *P* value of 0.04 (Fig. 9).

As shown in Table 8, there was no statistically significant difference in the post-operative echocardiographic data between patients in groups I and II (Fig. 10).

4.3. Pre-operative atrial electromechanical interval in both groups

It was found that the mean value of the AEMI in group I (having post-CABG AF) was 136.1 ± 5.6 ms and in group II was

Table 6 Pre-operative mean P wave duration in the two groups.

Minimum P wave duration (ms)	Group I	Group II	*P* value
Range	67–78	60–77	
Mean value	71	70.6	0.64
Standard deviation	4.3	4.06	

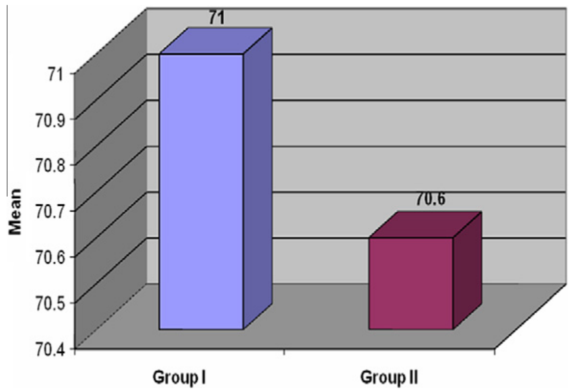

Figure 8 Comparison between the post-operative mean value of P wave in groups I and II.

Table 7 Pre-operative mean value of P wave dispersion in the two groups.

P wave dispersion (ms)	Group I	Group II	*P* value
Range	19–32	19–28	
Mean value	26	23	0.04
Standard deviation	4.7	4.7	

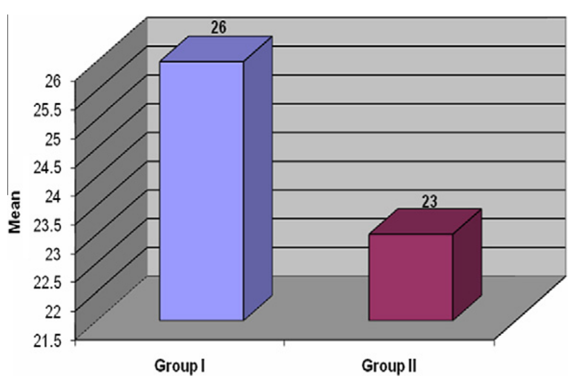

Figure 9 The mean value of P wave dispersion in groups I and II.

Table 8 Pre-operative echocardiographic data of patients in groups I and II (mean values).

Variable	Group I	Group II	*P* value
LVEDd	4.97	5.2	0.52
LVEsd	3.32	3.46	0.94
IVS	0.96	0.875	0.305
Pw	1.030	0.83	0.129
FS	28.5	33.9	0.252
EF	59.6	62.25	0.415
LAD	3.63	3.475	0.225
LAVOL	60.4	53.6	0.139

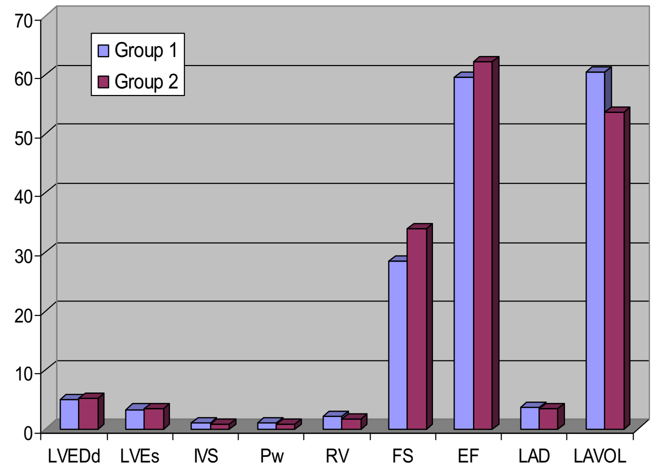

Figure 10 The pre-operative echocardiographic data in the patients of groups I and II.

Table 9 Comparison between mean AEMD in groups I and II.

AEMI	Group I	Group II	*P* value
Max value	145	140	
Min value	125	72	
Mean value	136.1	93.7	0.001
Standard deviation	5.66	19.1	

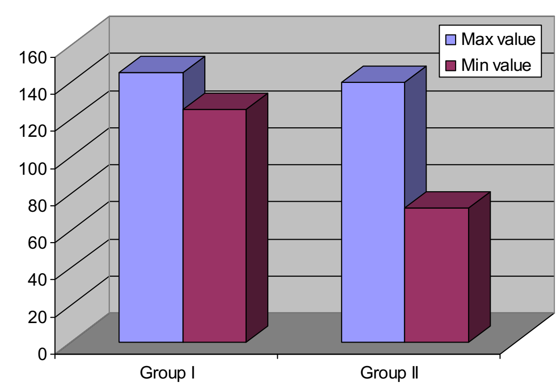

Figure 11 Comparison between the maximum and minimum values of the AEMI in groups I and II.

93.7 ± 19.1 ms with a significant difference ($P = 0.001$) (Table 9, Fig. 11).

4.4. The receiver operator characteristic (ROC) analysis

It was found that the best cut of limit of the AEMI done to patients before the CABG operation as a predictor of post-operative AF was 120 ms which achieves 100% sensitivity and 99% specificity (Fig. 12).

So patients with AEMI more than 120 ms is highly susceptible for the occurrence of post-operative AF with a sensitivity of 100% and specificity of 99%.

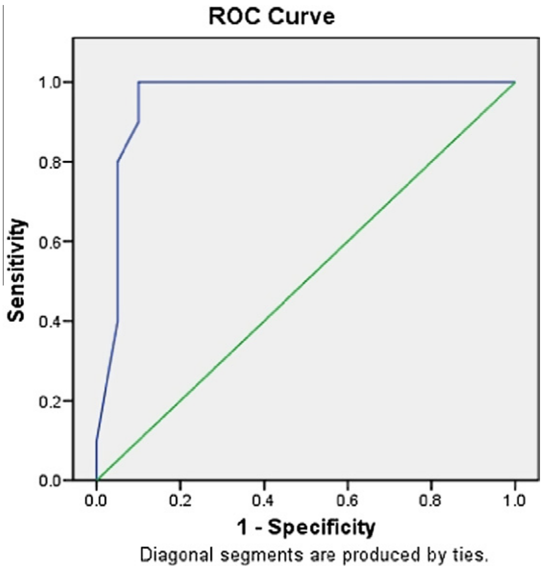

Figure 12 ROC curve for AEMI.

Also from the previous curve it was found that the area under the curve was 0.955 with an asymptomatic 95% confidence interval of 0.87 as a lower bound and 1.032 as an upper bound indicating that the AEMI is strongly significant in the prediction of post-operative AF.

5. Discussion

Atrial fibrillation is one of the most common complications occurring after cardiac surgery. As many as 10–40% of all patients undergoing CABG experiencing new onset post-operative AF usually occurring between second and fourth post-operative days.[15,16] With a peak incidence on postoperative day 2, 70% of patients develop this arrhythmia before the end of post-operative day 4.[4]

Although AF is usually benign, it may result in hemodynamic compromise, thrombo-emboli, stroke and an increase in hospital stay.[17,18] Moreover Rollo et al.[19] stated that post-operative AF was found to be 26 ms, an independent predictor of long-term mortality.

In the present study, it was found that RCA disease was documented in 40% of the patients and was more prevalent in group I than in group II where 80% of the patients who developed AF had RCA disease detected by pre-operative coronary angiography. The difference between groups I and II was statistically significant (P value = 0.002).

This was supported by a study done by Kudret et al.[20] they showed that RCA disease was found in 12.63% of patients who developed post-operative AF vs 7.2% of patients without post-operative AF. The difference was statistically significant (P value = 0.003).

Lisa et al.[21] reported RCA disease as an independent factor of post-CABG AF. They found that 168 patients with proximal or mid-RCA stenosis (33.9%) had post-operative AF with a P value of 0.001. In that study there was no significant difference between the AF and non-AF group regarding gender, age and/or LV function.

It is known that cardiopulmonary bypass reduces serum magnesium level due to hemodilution. Hemodilution at the start of CPB causes a 17% decrease in plasma magnesium which can persist until the first post-operative day. Increases in the renal excretion of magnesium also contribute significantly to hypomagnesaemia.[22]

Magnesium plays an important role in protecting the myocardium against the damaging effects of intracellular accumulation of calcium.[23]

In the present study, we evaluated the relationship between total serum magnesium level and the incidence of post operative AF. Decrease post-CABG serum Mg was found to be significant in group I. Serum Mg was 1.835 mg/dl in group I while in group II it was 2.00 mg/dl with a calculated P value of 0.004.

This result was supported by another study done by Mahdi et al.[24] They studied 170 patients undergoing CABG of whom 53 patients (31%) developed AF. They reported that post-CABG serum Mg was lower in patients who developed AF as 2.37 mg/dl vs 2.49 mg/dl in those who did not develop post-CABG AF with a P value of 0.001.

Mathew et al.[25] stated that peri-operative Mg^{2+} therapy in patients undergoing cardiac surgery should be carefully guided by plasma Mg^{2+} levels. Patients with a left ventricular ejection fraction greater than 40% who are hemodynamically stable but at an increased risk for peri-operative arrhythmias may benefit from Mg^{2+} administration during CPB. The routine administration of Mg^{2+} in all CABG patients undergoing cardiopulmonary bypass, especially in those with renal dysfunction, an increased risk of bleeding, or receiving concomitant nitrate or angiotensin-converting enzyme inhibitor therapy, is not currently justified.

In the present study it was found that the maximum duration of P wave was prolonged in patients in group I than those in group II (97.7 vs 94), respectively, with a calculated P value of 0.02.

These results are in agreement with those reported by David et al.[26] They studied 1508 patients of whom 503 patients (33.7%) developed AF. They found that P wave duration > 110 ms was independent risk factor for post-CABG AF.

P-wave dispersion constitutes a recent contribution to the field of noninvasive electrocardiology and is defined as the difference between the longest and the shortest P wave duration recorded from surface electrocardiographic (ECG) leads. Improvement in the methodology of recording and analyzing P wave inscriptions may lead to the widespread use of this ECG marker in various clinical settings and particularly in the assessment of risk for atrial fibrillation (AF).[11]

In the present study, the calculated P wave dispersion was longer in group I patients (26 ms) than those of group II (23 ms). The difference was statistically significant (P value = 0.04).

From the previous data both max P wave duration and P wave dispersion could be used to predict post-CABG AF.

These results are in agreement with those reported by Kloter et al.[27] who showed that P-wave dispersion was significantly increased in 47 patients who developed AF after coronary artery bypass surgery (49 ± 12 ms) as compared to 60 patients with no post-operative AF (41 ± 12 ms, P = 0.0009).

These results are also in agreement with those reported by Halil et al.[28] where post-operative AF developed in 17 (24%) cases of 70 patients. The P wave dispersion was found to be significantly higher pre-operatively in patients with post-CABG AF 60 ± 19 vs 47 ± 13, $P = 0.003$.

In another study done by Majid et al.[29] which included 302 patients undergoing CABG of whom 46 patients (15%) developed AF. The main finding of the study was that abnormal P-wave morphology is the main independent predictor for the development of postoperative AF (P value = 0.0001), the risk being 12 times higher in the patients with P-wave abnormality compared with those with normal P-wave morphology.

This could be related to the fact that abnormal P-wave morphology reflects abnormality of LA size, interatrial conduction delay and LA structural abnormalities.

In the present study we found that the AEMI was significantly longer in patients who developed post-operative atrial fibrillation than those who did not develop post-operative AF, where the mean value of the AEMI in patients in group I was 136.1 ms and in those in group II was 93.7 ms with a calculated P value of 0.001 with a sensitivity and specificity of 100% and 99%, respectively, indicating that AEMI is highly significant in predicting post-CABG AF.

Also it was found in our study that the post-operative AF is liable to occur in patients with the AEMI above 120 ms.

These results are in agreement with the results of a previous study done by Roshanali et al.[14] They showed that prolonged AEMI was detected in patients who showed post-CABG AF compared with those who remained in sinus rhythm after CABG (141.9 ± 13.4 vs 100.3 ± 10.3 ms, respectively; $P < 0.0001$).

Also results of the present study are in agreement with those reported by Omi et al.[10] who evaluated the AEMI via Doppler tissue to test its clinical feasibility for detecting atrial abnormalities in AF. Using Doppler tissue, Omi and associates measured the time intervals from the onset of the P wave until backward motions of the right (R-PC) and left (L-PC) atrioventricular rings in the apical 4-chamber view corresponding to the atrial contractions. They demonstrated that both R-PC and L-PC intervals in the AF group were significantly longer than those in the control group (74 ± 11 vs 61 ± 11 ms, $P < 0.005$; and 120 ± 15 vs 90 ± 11 ms, $P < 0.0001$, respectively). Using the criterion of L-PC interval > 112 ms as an atrial impairment of paroxysmal AF yielded sensitivity, specificity, and a positive predictive value of 73%, 93%, and 93%; using an L-PC interval > 104 ms (the value with the largest sum of sensitivity and specificity) yielded values of 87%, 93%, and 93%, respectively.

Some of the demographic factors that have been reported as predictors of post-CABG AF can increase fibrosis and lead to consequent atrial refractoriness and conduction delay. Because the prolongation of the AEMI can be explained not only by LA enlargement but also by increased time delay from electric activation in the atrium to atrial myocardial contraction, Creswell et al.[30] stated that the AEMI can totally and significantly reflect the atrial impairment and predict post-CABG AF.

In the present study pre-operative factors such as age, sex, hypertension, and use or withdrawal of medication have not been shown to be risk factors for postoperative AF. These results are in agreement with those reported by Hakala et al.[30] who stated that none of these factors is powerful enough to predict postoperative AF after CABG.

Although not found to be significant in the present study most probably due to small sample or decrease the mean age of patients undergoing CABG in our study (53.4 years), many studies illustrated that The most consistent predictor for the development of post-CABG AF is advanced age.[31,32] In a study investigating the effect of age on the incidence of post-CABG AF, Mathew et al.[25] had documented that for every decade there is a 75% increase in the odds of developing post-operative AF and concluded that, on the basis of age alone, anyone older than 70 years is considered to be at high risk for developing AF. It is indeed well documented that advanced age is associated with degenerative and inflammatory modifications in atrial anatomy (dilation, fibrosis), which cause alterations in atrial electrophysiological properties (shortness of effective refractory period, dispersion of refractoriness and conduction, abnormal automaticity, and anisotropic conduction.

In the present study none of the echo parameters namely EF, FS, LAD, LA volume, PWT, IVS, LVEDd, LVESd were found to be significant in predicting post-CABG AF. This may be due to small sample size (30 patients) and exclusion of patients with CHF, history of AF or valvular lesion.

The results of the present study are not in agreement with the results of Halil et al.[28] In that study post-operative AF developed in 17 (24%) cases of 70 patients where the AF group had left ventricular systolic dysfunction 56 ± 13% vs 56 ± 8%, $P = 0.042$, pre-operatively; 49 ± 8% vs 60 ± 10%, $P = 0.001$, post-operatively and a larger left atrium 46 ± 5 vs 39 ± 5 mm, $P < 0.001$, pre-operatively and 44 ± 7 vs 39 ± 5 mm, $P = 0.046$, post-operatively than the group without AF.

In the present study the LA volume was not found to be significant as a predictor of AF. The mean value of LAV in group I was 60.4 vs 53.6 in group II with a P value of 0.139. Several studies have reported that the LA dimensions in patients with paroxysmal AF are not necessarily larger than those in control subjects.[33,34] Furthermore, the relationship between the LA chamber size estimated by echocardiography and lone paroxysmal AF is controversial. Echocardiographic LA chamber size usually is measured as a short-axis dimension in the parasternal and apical views, but this method possibly is insensitive in the detection of LA enlargement.[35] Transmitral flow velocity during early diastolic filling (E), atrial contraction (A), and E/A ratio are affected in paroxysmal AF. Decreased A velocity is correlated with reduced atrial contraction.[36] Decreased E/A ratio is related mainly to left ventricular diastolic dysfunction and not directly to atrial impairment.[37] Both parameters are less sensitive and less specific because they are influenced by such cardiac conditions as heart rate, preload, and afterload.[38]

The results of the present study are not in agreement with those reported by Martin et al.[39] that included 205 patients undergoing CABG, post-operative atrial fibrillation occurred in 84 patients (41.4%) at a median of 1.8 days after cardiac surgery. The LAV was significantly larger in patients in whom AF developed (49 ± 14 ml/m^2 vs 39 ± 16 ml/m^2, $P = 0.0001$). Patients with LAV > 32 ml/m^2 had an almost five-fold increased risk of post-operative AF, independently of age and clinical risk factors, left atrial volume was the only independent predictors of post-operative AF.

M-mode Doppler tissue echocardiography enabled us to evaluate the validity of the AEMI as a predictor of post-CABG AF. This index, which is in-expensive and accessible, showed that patients with a larger AEMI were prone to develop AF rather than remain in sinus rhythm after CABG.[14]

The results of our study are in agreement with those of other studies showing that the AEMI was a useful parameter for detecting atrial impairment. Therefore, the AEMI can be used as a reliable index to determine patients at high risk of post-CABG AF, with a larger AEMI denoting a higher probability of post-CABG AF. Consequently, effective prophylactic measures can be targeted only at patients with a prolonged AEMI.

Finally, we concluded that the main predictors of occurrence of post-CABG AF are AEMI, maximum P wave duration, P wave dispersion, post-operative serum magnesium and RCA disease.

References

1. Hakala T, Hedman A. Predicting the risk of atrial fibrillation after coronary artery bypass surgery. *Scand Cardiovasc J* 2003;**37**: 309–15.
2. Creswell L, Schuessler RB, Rosenbloom M, et al. Hazards of postoperative atrial arrhythmias. *Ann Thorac Surg* 1993;**56**: 539–49.
3. Creswell L, Damiano R. Postoperative atrial fibrillation: an old problem crying for new solutions. *J Thorac Cardiovasc Surg* 2001;**121**:638–41.
4. Aranki S, Shaw D, Adams D, et al. Predictors of atrial fibrillation after coronary artery surgery: current trends and impact on hospital resources. *Circulation* 1996;**94**:390–7.
5. Borzak S, Tisdale J, Amin N, et al. Atrial fibrillation after bypass surgery: does the arrhythmia or the characteristics of the patients prolong the hospital stay. *Chest J* 1998;**113**:1489–91.
6. Hravnak M, Hoffman LA, Saul MI, Zullo TG, et al. Predictors and impact of atrial fibrillation after isolated coronary bypass grafting. *Crit Care Med* 2002;**30**:330–7.
7. Daoud E, Strickberger S, Deeb G, et al. Preoperative amiodarone as prophylaxis against atrial fibrillation after heart surgery. *N Engl J Med* 1997;**337**:1785–91.
8. Guarnieri T, Nolan S, Gottlieb S, et al. Intravenous amiodarone for the prevention of atrial fibrillation after open heart surgery. *J Am Coll Cardiol* 1999;**34**:343–7.
9. Mahoney E, Thompson T, Williams J, et al. Cost-effectiveness of targeting patients undergoing cardiac surgery for therapy with intravenous amiodarone to prevent atrial fibrillation. *J Am Coll Cardiol* 2002;**40**:737–45.
10. Omi W, Nagai H, Takamura M, et al. Doppler tissue analysis of atrial electromechanical coupling in paroxysmal atrial fibrillation. *J Am Soc Echocardiogr* 2005;**18**:39–44.
11. Polychronis E Dilaveris, John E, Elias J, et al. P wave duration and dispersion statistical analysis. *AHJ* 1998;**135**: 733–8.
12. Lang Roberto M, Michelle Bierig, Richard B, et al. Recommendations for chamber quantification: a report from the American Society of Echocardiography's Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European Society of Cardiology. *J Am Soc Echocardiogr* 2005;**18**(12):1441–63.
13. Alan D, Ehler Donna, Adams David, et al. Guidelines for the cardiac sonographer in the performance of echocardiography: recommendations of the American Society of Echocardiography Council on Cardiac Sonography. *J Am Soc Echocardiogr* 2001;**14**:417–20.
14. Roshanali Farideh, Hossein Mohammad, Ali Mohammad, et al. Prediction of atrial fibrillation via atrioelectromechanical interval after CABG. *Circulation* 2007;**116**:2012–7.
15. Ommen S, Odell J, Stanton M. Atrial arrhythmias after cardiothoracic surgery. *N Engl J Med* 1997;**336**:1429–34.
16. Svedjeholm R, Hakanson E. Predictors of atrial fibrillation in patients undergoing surgery for ischemic heart disease. *Scand Cardiovasc J* 2000;**34**:516–21.
17. Reed G, Singer D, Picard E, et al. Stroke following coronary artery bypass surgery. *N Engl J Med* 1988;**319**:1246–50.
18. Fuller J, Adams G, Buxton B. Atrial fibrillation after coronary artery bypass grafting. Is it a disorder of the elderly? *J Thorac Cardiovasc Surg* 1989;**97**:821–5.
19. Rollo P Villareal, Hariharan Ramesh, Brant C, et al. Postoperative atrial fibrillation and mortality after coronary artery bypass surgery. *J Am Coll Cardiol* 2004;**43**:724–32.
20. Kudret Aytemira, Serdar Aksoyeka, Necla Ozera, et al. Atrial fibrillation after coronary artery bypass surgery: P wave signal averaged ECG, clinical and angiographic variables in risk assessment. *Inter J Cardiol* 1998;**69**:49–56.
21. Lisa Mendes, Gilbert P, Connelly M, et al. RCA stenosis: an independent predictor of atrial fibrillation after CABG. *J Am Coll Cardiol* 1995;**25**:198–202.
22. Inoue S, Akasawa S, Nakaigawa Y, et al. Changes in plasma total and ionized magnesium concentrations and factors affecting magnesium concebtrations during cardiac surgeru. *J Anesth* 2004;**18**:216–9.
23. Boyd W, Thomas J. Pro: magnesium should be administered to all coronary artery bypass graft surgery patients undergoing cardiopulmonary bypass. *J Cardiothorac Vasc Anesth* 2000;**14**: 339–43.
24. Mahdi Najafi, Babak Haghighat, Hossein Ahmadi. Relation between serum magnesium level & arrhythmia following CABG. *Anesthesia J* 2007;**139**:110–22.
25. Mathew J, Fontes M, Tudor J, et al. A multicenter risk index for atrial fibrillation after cardiac surgery. *JAMA* 2004;**291**: 1720–9.
26. David Mason, John M, Michel D, et al. *Coronary artery bypass graft. Cleveland clinic cardiac surgery text book*. 2nd ed. 2004. p. 12–145 [ch. 1–3].
27. Kloter Weber U, Osswald S, Huber M, et al. Selective versus nonselective antiarrhythmic approach for prevention of atrial fibrillation after coronary surgery: is there a need for preoperative risk stratification? A prospective placebo-controlled study using low-dose sotalol. *Eur Heart J* 1998;**19**:749–800.
28. Halil I, Enver Atalar, Birkan Akbulur, et al. The role of surface ECG and transthoracic echo for predicting post CABG-AF. *Saudi Med J* 2008;**29**:352–6.
29. Majid Haghjoo, Hossein Basiri, Mehrasa Salek. Predictors of postoperative atrial fibrillation after coronary artery bypass graft surgery. *Indian Pacing Electrophysiol J* 2008;**28**:167–72.
30. Hakala T, Vanninen E, Hedman A, et al. Analysis of heart rate variability does not identify the patients at risk of atrial fibrillation after coronary artery bypass grafting. *Scand Cardiovasc J* 2002;**36**:167–71.
31. Mathew J, Parks R, Savino J, et al. Atrial fibrillation following coronary artery bypass surgery: predictors, outcomes, and resource utilization. *JAMA* 1996;**276**:300–6.
32. Almassi GH, Schowalter T, Nicolosi AC, et al. Atrial fibrillation after cardiac surgery: a major event. *Ann Surg* 1997;**226**:501–11 [discussion, 511–513].
33. Takahashi N, Imataka K, Seki A, et al. Left atrial enlargement in patients with paroxysmal atrial fibrillation. *Japan Heart J* 1982;**23**:677–83.
34. Rostagno C, Olivo G, Comeglio M, et al. Left atrial size changes in patients with paroxysmal lone atrial fibrillation: an echocardiographic follow-up. *Angiology* 1996;**47**:797–801.
35. Loperfido F, Pennestri F, Digaetano A, et al. Assessment of left atrial dimensions by cross sectional echocardiography in patients with mitral valve disease. *Br Heart J* 1983;**50**:570–8.
36. Barbier P, Alioto G, Guazzi M. Left atrial function and ventricular filling in hypertensive patients with paroxysmal atrial fibrillation. *J Am Coll Cardiol* 1994;**24**:165–70.

37. Thamilarasan M, Grimm R, Rodriguez L, et al. Left ventricular diastolic dysfunction in lone atrial fibrillation determined by Doppler tissue imaging of mitral annular motion. *Am J Cardiol* 2000;**86**:1026–9.
38. Nishimura R, Abel M, Hatle L, et al. Assessment of diastolic function of the heart: background and current applications of Doppler echocardiography, part II: clinical studies. *Mayo Clin Proc* 1989;**64**:181–204.
39. Majid Haghjoo, Hossein Basiri, Mehrasa Salek. Predictors of postoperative atrial fibrillation after coronary artery bypass graft surgery. *Indian Pacing Electrophysiol J* 2008;**28**:167–72.